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DISTRIBUTION OF BARK BEETLE ATTACKS ON PONDEROSA PINE TREES IN MONTANA

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ABSTRACT

The boles of 71 mature ponderosa pine trees killed by Dendroctonus brevicomis LeConte (Coleoptera: Scolytidae) were analyzed to determine the distribution of the attacks by endemic populations of this bark beetle and those of several phloem-feeding associates. The longitudinal-circumferential distribution of the attacks fitted diagrammatically into four distinguishable bole infestation patterns. The characteristics of the patterns and similarities with comparable attacks of D. brevicomis in northeastern California are discussed.

Forest entomologists studying the western pine beetle (Dendroctonus brevicomis LeConte (Coleoptera: Scolytidae)) have periodically investigated the feasibility of predicting changes in population levels and consequent outbreak patterns by using measurable field factors. One approach to this objective has been to study the identity and dependability of the attack patterns made by this insect and its principal phloem-feeding insect associates on the boles of ponderosa pine host trees. Studies as early as 1912 in California[2] showed that attacks by the pine beetle produce distinctive distribution patterns on the boles of these trees during endemic and epidemic cycles of its populations. Attack patterns differ between individual host trees of varying ages and degrees of vigor and between geographic areas. The pattern is also affected by the particular combination of associated insects that attack the tree, by the season of the attack, and by the density of the pine beetle population.

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[2] Miller, J. M., and F. P. Keen. Biology and control of the western pine beetle. U.S. Dep. Agr. Misc. Pub. 800. 381 pp. 1960.

Since the complex of bark beetles found attacking ponderosa pine in parts of California differs from that found in the northern Rocky Mountains, it seemed likely that the bole attack patterns would also differ. To identify and describe the characteristic patterns, a study was conducted between 1949 and 1964 in mature forests of ponderosa pine in Montana west of the Continental Divide.

METHODS

Newly killed ponderosa pine trees were located and measured annually for 15 years on 35 plots totaling 560 acres and containing 11,946 living pine trees in stands classified as mature or overmature. As part of a concurrent study, the living trees had already been measured for gross board-foot volume and had been classified by age, general vigor, and risk of attack by *Dendroctonus brevicomis*. Age and vigor classes were based on the Ponderosa Pine Tree Classification[3] and risk rating was determined by the Ponderosa Pine Risk Rating System.[4]

The tree-mortality measurements made annually during the autumn months revealed a total of 98 ponderosa pine trees that had died during the study period, presumably from attacks of *D. brevicomis*. Each of these trees was felled and examined within a year after death. The boles of the trees were analyzed to determine the cause of death and the distribution and other features of the attacks by *D. brevicomis* and its associates.

For the analysis, irregular sections of bark, each amounting to 0.5 square foot, were removed from the north, east, south, and west sides at 10-foot intervals along the boles of the felled trees. The inner surfaces of the bark samples were first examined generally for egg galleries and larval mines of *D. brevicomis* and other phloem-feeding insects. The examinations disclosed that 27 of the 98 felled pine trees died from causes other than attacks by *D. brevicomis*. The remaining 71 pine trees had been attacked and killed by *D. brevicomis* alone or in conjunction with attacks of insect associates.

The areas of cambium attacked by each species of insect in the 71 beetle-killed trees were then specifically located and their extent was determined by further examinations between the sampling points when necessary. Results were sketched on bole diagrams. Areas of cambium that were unattacked or had been dead for two or more years previous to the analyses were also measured and sketched.

The bole diagrams for the 71 beetle-killed pine trees were separated according to three diameter classes to disclose any possible relation of attack patterns to age classes and sizes. Basal diameter classes of 12 to 18 inches, 20 to 28 inches, and 30 to 54 inches were used for the grouping. The diagrams were then studied to detect visually discernible bole infestation patterns, or types, within each diameter class. Four common types were seen to exist, and composite diagrams of these types were drawn.

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[3] Keen, F. P. Ponderosa pine tree classes redefined. J. Forest. 41(4): 249-253. 1943.

[4] Salman, K. A., and J. W. Bongberg. Logging high risk trees to control insects in pine stands in northeastern California. J. Forest. 40(7): 533-539. 1942.

An attempt was then made to draw a relation between these types and the age, vigor, and risk rating of the trees in each type group. To this end, the proportions of living and beetle-killed trees in the various age, vigor, and diameter classes and risk ratings were recorded.

RESULTS

The four reasonably distinctive bole infestation types identified in the study are represented by composite diagrams in figure 1. The diagrams show the mean linear and circumferential distribution of attacks by *Dendroctonus brevicomis* and the following species of phloem-feeding beetles:

Family Scolytidae
  Dendroctonus ponderosae Hopkins (=*monticolae* Hopkins)
  Ips pini (Say) (=*oregonis* (Eichhoff))
  Ips emarginatus (LeConte)

Family Buprestidae
  Melanophila californica Van Dyke

As evident in the diagrams, the species composition of the attack patterns and the distribution of the attacks by the several insect species differed slightly in the three diameter classes within bole infestation types I and II. Patterns of types I and II were found in trees of all three diameter classes, but types III and IV were found only in trees of a single diameter class.

Populations of *D. brevicomis* on the plots remained at endemic levels throughout the study. The mean annual gross mortality of ponderosa pine from beetle attacks during this period, for instance, was 24 board feet per acre, an amount believed to be well under the probable gross increment for mature ponderosa pine stands in this region.

There were no marked differences in salient characteristics of the trees classified under the four bole infestation types (table 1). There were, however, a few gross differences between the premortality characteristics of beetle-killed trees and those of the average living ponderosa pine trees on the plots used by the study:

Characteristics	Beetle-killed trees	Living trees
Age class	4	4
Vigor class	D	C
Risk rating	3 or 4	2
Gross board-foot volume	755	776

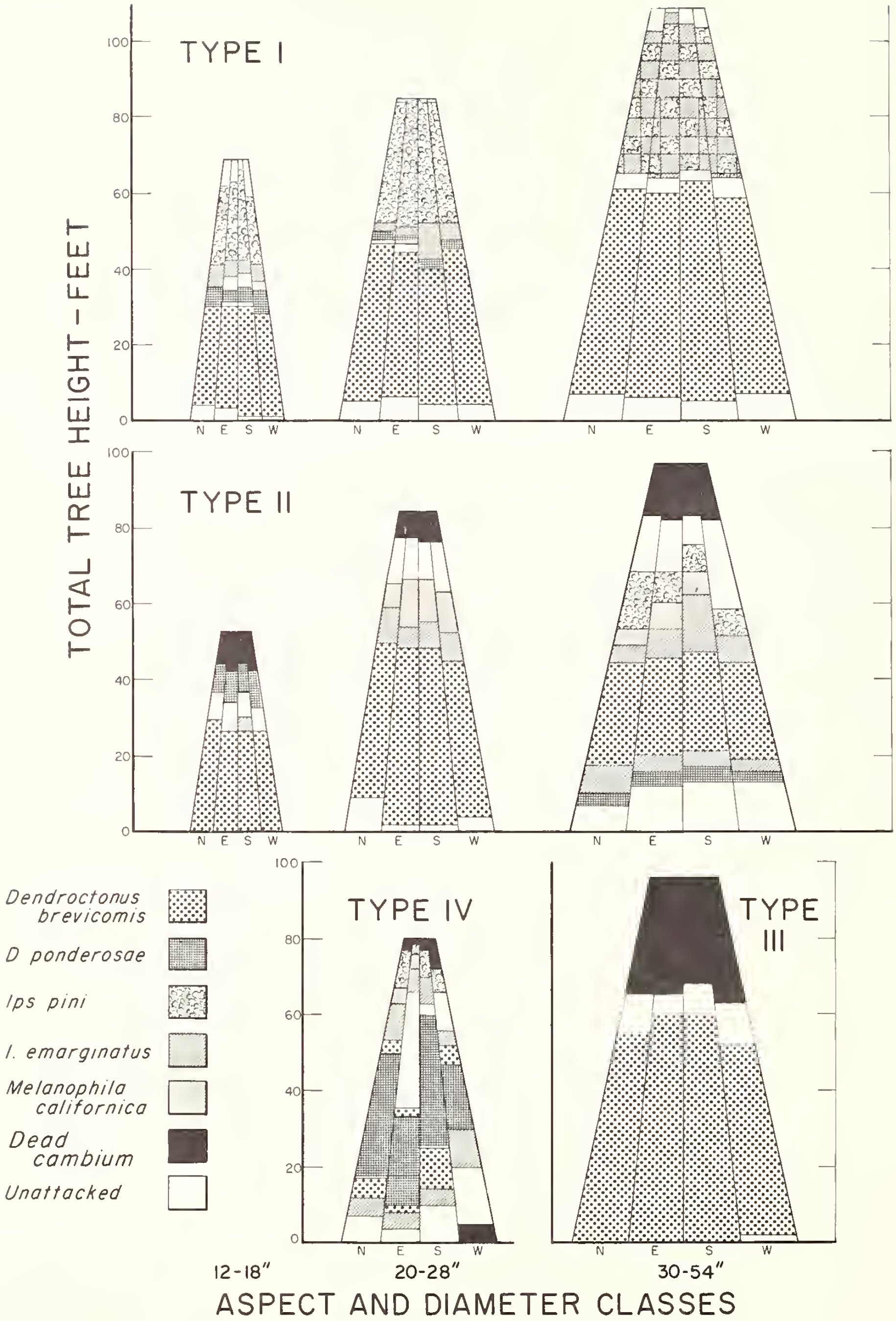

Figure 1.--Composite diagrams of four bole infestation types. The diagrams indicate the distributional patterns of attacks by endemic populations of Dendroctonus brevicomis and those of its principal phloem-feeding insect associates in mature ponderosa pine trees in western Montana from 1949 to 1964.

Table 1.--Some characteristics of beetle-killed ponderosa pine trees according to type of bole infestation pattern

Bole infestation type	Basal diameter class	Number of trees sampled	Mean tree size		Predominant classifications		
					Tree classification		Risk rating[3]
			Basal diameter	Total height	Age[1]	Vigor[2]	
	Inches		Inches	Feet			
I	12-18	10	16	69	4	D	3
	20-28	18	24	85	4	C	2, 3
	30-54	12	37	109	4	C	3, 4
II	12-18	4	15	52	4	D	2, 3
	20-28	13	24	84	4	C, D	3
	30-54	4	36	67	4	C, D	2, 4
III	30-54	7	36	97	4	D	4
IV	20-28	3	25	80	4	C	2, 3, 4
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[1] Age: 1, young; 2, immature; 3, mature; 4, overmature.
[2] Vigor: A, very good; B, good to fair; C, fair to poor; D, very poor.
[3] Risk (of beetle attack): 1, low; 2, moderate; 3, high; 4, very high.

Areas of cambium occupied by each insect species shown in figure 1 were usually occupied by that species exclusively. Areas occupied by D. brevicomis included scattered patches of uninfested cambium in many of the sampled trees. In contrast, areas occupied by Ips pini were completely utilized by its egg galleries or by the feeding of larvae or new adults.

By the time the beetle-killed trees were analyzed, most of them had been abandoned by the broods of D. brevicomis or the phloem-feeding insect associates that had developed in them. The former presence of the beetles was identified and dated by the relative state of deterioration of the phloem tissue as judged from experience by the writer, and by egg gallery and larval mine patterns inscribed on the inner bark surface.

A comparison of the bole infestation types observed in Montana with those from a comparable outbreak level and host forest condition in northeastern California, as reported by J. W. Johnson,[5] is given in table 2.

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[5] Johnson, J. W. Composition studies of the 1941 season, Modoc National Forest. Unpubl. rep., U.S. Dep. Agr., Bur. Entomol. and Plant Quar., Berkeley, Calif. 13 pp. Dec. 17, 1940.

Table 2.--Comparison of distribution of types of bole infestation in trees studied in Montana and California

Type[1]	Dominant species	Distribution of trees studied		
		Montana	California	
		1949-1964	1939	1940
		Percent		
I	Dendroctonus brevicomis-Ips pini	56.3	45.7	14.3
II	Dendroctonus brevicomis-mixed species	29.6	8.6	2.4
III	Dendroctonus brevicomis	9.9	18.6	9.5
IV	Dendroctonus ponderosae-Dendroctonus brevicomis-mixed species	4.2	5.7	
V	Melanophila californica-Dendroctonus brevicomis		14.3	40.5
VI	Melanophila californica-Dendroctonus brevicomis-Ips pini		4.3	26.2
VII	Ips pini-Dendroctonus brevicomis		2.8	7.1
		100.0	100.0	100.0

[1] Roman numerals (V-VII) are assigned to California types for convenience.

From Johnson's diagrams and from the study observations, some general comparisons may be made. Although it plays an aggressive, tree-killing role in northeastern California (types V and VI), the buprestid *Melanophila californica* was almost unnoticeable as a secondary infester of mature ponderosa pine trees in western Montana during the study period. Similarly, the initial top-killing of mature ponderosa pine trees in California by *Ips pini* (type VII), followed by attacks on these trees by the western pine beetle, was not observed in Montana. Attacks of *I. pini* in Montana, while still confined largely to the upper boles of pine trees, almost always followed initial attacks by *D. brevicomis*. The remaining four bole infestation types previously identified in California (types I-IV) were recognized in western Montana.

DISCUSSION

Bole infestation types from endemic populations of Dendroctonus brevicomis in western Montana and northeastern California showed certain similarities, although this was not true of types from other parts of California. Bark beetle faunal complexes found in western Montana and northeastern California appear to be quite similar, even though the ponderosa pine stands in the two regions bear, in part, different forest cover type designations.[6] The study has made evident the following characteristics of bole attack patterns produced by endemic populations of D. brevicomis in western Montana:

1. The patterns indicate that ponderosa pine trees killed by the beetle are predominantly those classified as poorer in vigor and higher in risk of beetle attack than trees representative of the stands as a whole.

2. Endemic populations of D. brevicomis do not fully utilize the available bole cambium in the trees they attack. This may result more from the primary attraction of scattered host trees, which divides the low level populations of attacking pine beetles, than from interspecific competition from attacks of associated insects. From observation and from other studies, we know that attacks by these associates ordinarily follow those of the pine beetles after a time lag that would allow the available pine beetle population sufficient opportunity to utilize fully the acceptable cambium.

3. The attack characteristics in (2) above undoubtedly enable regionally important insect associates to utilize greater amounts of unattacked cambium for the development of their own broods in trees initially attacked by D. brevicomis.

4. Attacks of D. brevicomis in most host trees come within reach of persons standing at the base of the trees, a feature that facilitates identification of trees attacked by this insect.

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[6] Western Montana: interior ponderosa pine and ponderosa pine--larch--Douglas-fir, types 237 and 214, respectively, of the Society of American Foresters. Northeastern California: interior ponderosa pine.

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